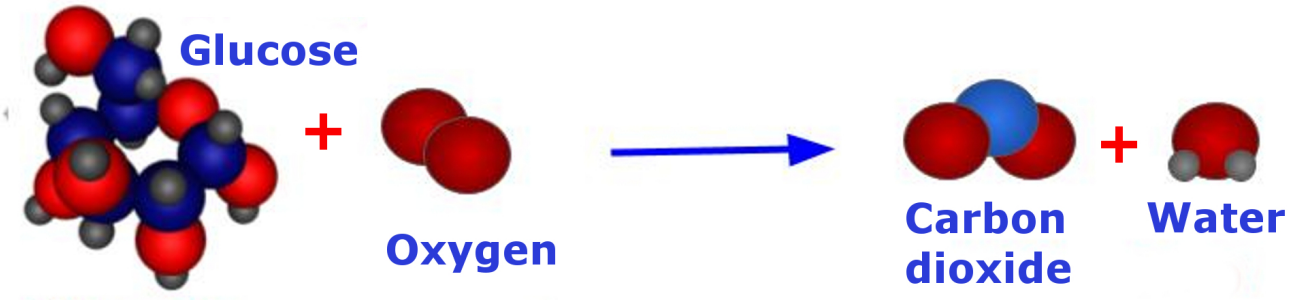
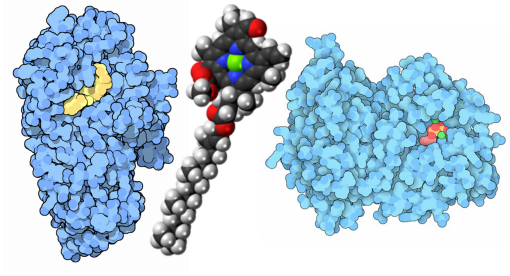
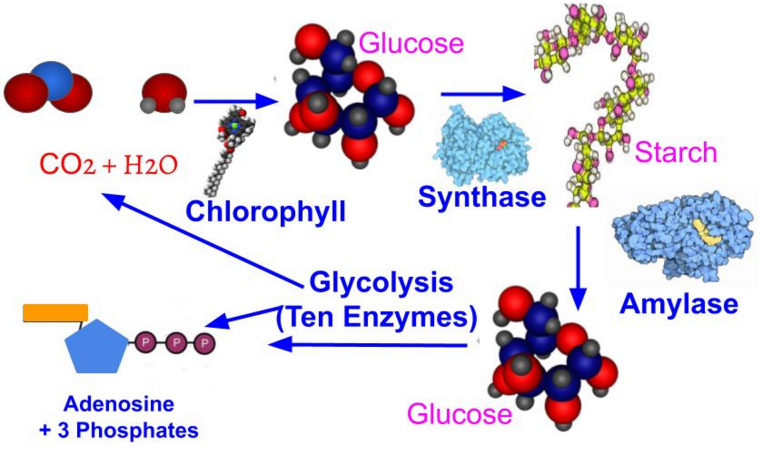
Living is surviving



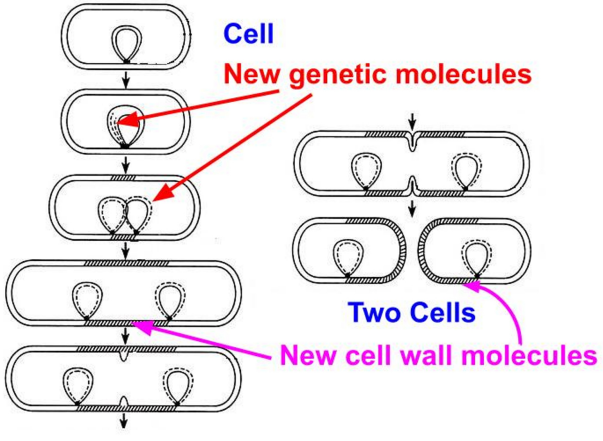


How can chemical reactions lead to the positive and negative feedback, required for living? As described earlier, there is often a barrier to the reaction between two molecules. For example, the reaction of a glucose molecule with oxygen {Picture above} will not start unless the temperature is increased. Living beings cannot tolerate such high temperatures. Even if the temperature is increased to start the reaction, the reaction would continue till all the available glucose is consumed. So, even those chemical reactions, required for living, and possible at the normal temperature of the living being will be useless if they complete too fast. So the organism should be able to control the chemical reactions, starting and stopping them as required. Living beings make long molecules called enzymes, with thousands of amino acids to do this. Every enzyme folds into a specific shape. The reactant molecules are temporarily captured into these folds highlighted in the picture above and the reaction takes place without any increase in temperature. The reaction products escape from the folds. By increasing and decreasing the number of enzyme molecules, the living beings ensure that



the feedback control takes place. Other enzymes are used to get the energy required to make enzymes and to destroy them as and when necessary.

Plants use chlorophyll, an enzyme, to produce glucose using water, carbon dioxide and energy from sunlight. {Picture left above} They then use another enzyme, synthase to convert the glucose into starch which is easier to store. But starch is not soluble in water. So when some cells require energy, the plant converts stored starch into glucose again, using yet another enzyme called amylase. Glucose being soluble is easily transported to all the cells by blood in animals and other fluids in plants. Individual cells use the energy available in the glucose molecule, by converting it back into carbon dioxide and water. This process attaches three phosphate groups to an adenosine molecule and requires ten different enzymes. The adenosine triphosphate is used by the cell in the various feedback loops required for life, including the preparation of these enzymes from genes and making copies of the genes. When adenosine triphosphate attaches to other biological molecules in the cell, their energy is enhanced. The barriers to chemical reaction are overcome and the reaction takes place. The adenosine loses the phosphate groups. Once again the energy from glucose is used to attach the phosphate groups to adenosine which then helps the completion of another reaction in the cell.



In the beginning, the egg shell contains only one living cell. The white and yellow liquids seen in the egg are raw materials providing molecules for the formation of the chick. For the one living cell to divide into two, first, a second copy of the genes has to be made. For this step itself, a number of proteins and enzymes are required. Copies of the specific genes required to make these genes have to be made. Unless some changes are made to this copy, it cannot be used to link the amino acids and make the enzyme molecule. The copy of a gene that can link amino acids is called the RNA and the original gene is called the DNA. Using the material available inside the egg, the RNA has to make the enzymes. Then the enzymes have to make a copy of the genes in the cell. At each step energy is required. And even more enzymes are required to process the raw materials in the egg and acquire energy. Once the copy of the entire gene is ready, the outer membrane of the cell has to be made larger and finally the two cells can be separated. {Picture above}

Each division doubles the number of cells. Each division involves the complex procedure described above. Further, after the first few divisions, the cells have to change. Only then, will cells for the various organs of the chick form by cell division. Eventually a chick with millions of cells breaks out of the egg shell. All the cells have come out of the first cell. So every cell has a copy of the complete set of genes of the chick. Even after birth, cells in a living chick or a human being are continuously dying and are being replaced by cell

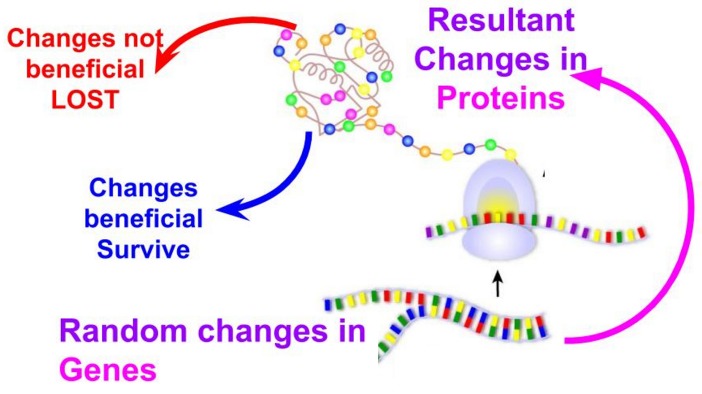
division. When cells divide in a particular organ, they do not change. Only cells required for that organ are formed. Most cells in a human body live only for about 24 hours or less. But the cells in the liver live for about a year. Only the cells in the brain do not divide and they live as long as the human being.

Even a single celled organism like the amoeba can form molecules with millions of atoms, modify the molecules when there are changes in the surroundings and maintain order inside the cell for some time. This ability of a single cell is perhaps the greatest mystery in all of creation.

Every step in the process of life has been separately investigated by scientists to confirm that life processes never violate laws of chemistry and physics. Humans have learnt to control these processes. That has many benefits from medicines for cancer to new food crops for the seven billion people on earth. The chemical reactions in living beings are extremely complex. So mistakes resulting in diseases and deaths are not a surprise. That trillions of living beings continued to live on earth for billions of years while the environment has been changing is however a great surprise.

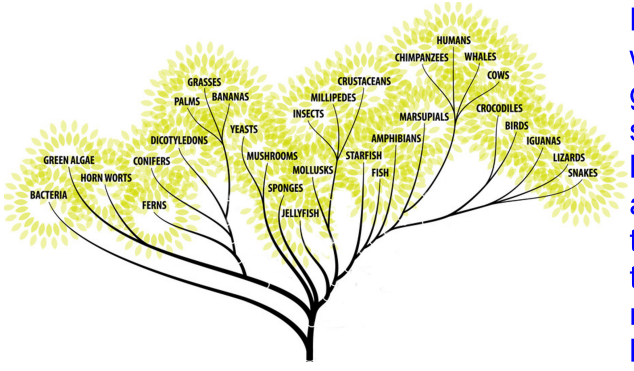
The genes of a living being and the genes of the next generation are never identical. One reason for such changes are mistakes that may occur in the preparation of the copies of gene molecules. Mixing of genes of the father and the mother is another reason, but this obviously does not occur in simple organisms like amoeba and even in some plants. Whenever there is a change in the gene molecule, there will be changes in the enzyme or protein made from that gene. The enzyme may work better or worse or even stop working completely. Since the mistakes are random changes, most often, the living being is harmed

by the mistakes. It may even die. But occasionally, the living being may also be benefited. {Picture right} More of its progeny may survive. This is the only true benefit. Merely the enzyme working better is not enough. The change in the genes should help the organism leave more progeny. Every living being dies. It only survives in the form of the progeny. This is the reason for the statement living is surviving.

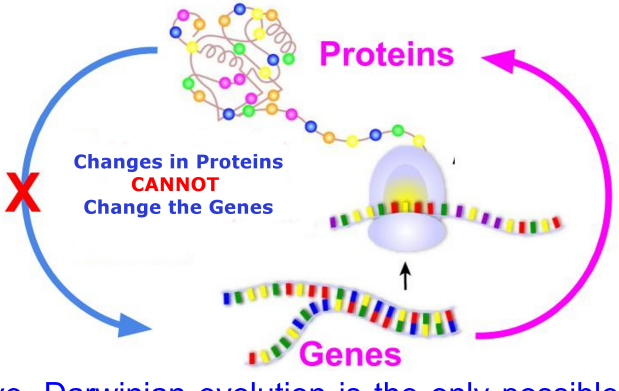


Availability of food and resources is always limited and all living beings have to compete for them. At every generation the animals with the changed gene will increase slightly. Most animals will not have a progeny because they cannot compete. So, even a small increase in the number of progeny is very important. If there is just a 1% increase, due to a change in the gene, after 100 generations, 99% of all the surviving animals will have the changed gene. Resources will never suffice. An amoeba reproduces every 8 minutes. So, if every successor has to successfully reproduce for 120 days, more atoms are required than are available in the total universe. Because resources are limited, every small increase in the number of progeny is very important for survival.

When genes change by accident, the changes in proteins could increase the number of progeny. When the changes in genes accumulate, new species of plants and animals are formed. All animals evolved from a common ancestor. This is the simplest description of



the theory of evolution developed by Charles Darwin. {Picture left} In Darwin's lifetime, there was no proper understanding of the role of genes. Darwin studied the anatomy or body structure of animals, the places where they lived in nature and the fossils of ancient animals available in his time to develop his theory. Like Dalton's atomic theory, Darwin's theory of evolution has also been changed by newer observations. But the core idea that all living beings including man find a place on the tree of life has not changed.



All living beings are made of the same amino acids and nucleotides. As mentioned earlier, this is a strong evidence of a common origin of all living beings. Further, as was mentioned, all processes in living beings obey the rules of chemistry. In the molecules, changes in genes can cause changes in proteins. But changes in proteins cannot cause changes in the genes. {Picture right} In nature, changes in genes are accidental. Some of these changes leave the living being with more progeny and they survive. Darwinian evolution is the only possible theory to agree with observations and experiments made on molecules.

One important step in the evolution of life on earth is the moving of animals from water to dry land. When there was intense competition for resources inside water, some organisms, due to an accidental change in genes developed an ability to partly live on land. This helped their survival since there was no competition for resources on land at that time. This is how organisms enter a previously unoccupied environment. This is how some organisms now live inside the intestines of all human beings. Some organisms live at volcanic vents under the sea where the temperature is 80^{o}C, where others cannot live. But living beings cannot detect an unoccupied place and modify their genes to occupy that place.

Before Darwin, La mack proposed that changes in animals are due to the changes in their living circumstances. For example, he thought that giraffes have long necks because for generations they have been trying to reach leaves on higher branches of trees and getting more food. Darwin had proved him wrong.

Modern Darwinian theory of accidental changes in genes, competition for resources and survival of the fittest is not acceptable for many. Some fear that this theory would be applied to human society and damage sympathy for the weak and cooperation among people. Others, with strong religious beliefs are not happy with the idea of man evolving out of animals and of life existing for billions of years before mankind. It is important to note that Darwinian evolution is useful for understanding nature, not useful for organizing human societies.